UNCOMPACTED VOID CONTENT OF FINE AGGREGATE
FOP FOR AASHTO T 304

Scope

02 This Field Operating Procedure (FOP) covers a method for determining the loose uncompacted void content of a sample of fine aggregate

Three procedures are included for the measurement of void content:

- **Standard Graded Sample (Method A)**
- **Individual Size Fractions (Method B)**
- **As-Received Grading (Method C)**

For Method A or C, the percent void content is determined directly, and the average value of two test runs is reported.

For Method B, the mean percent void content is calculated using the results from each of the three individual size fractions.

Significance

03 Methods A and B provide percent void content determined under standardized conditions which depend on the particle shape and texture of a fine aggregate. An increase in void content by these procedures indicates greater angularity, less sphericity, rougher surface texture, or some combination of these three factors.

04 Method C measures the uncompacted void content of the minus No. 4 portion of the as-received material. This void content depends on both grading as well as particle shape and texture.

The standard graded sample (Method A) is most useful as a quick test that indicates the particle shape properties of a graded fine aggregate. Typically, the material used to make up the standard graded sample can be obtained from the remaining size fractions after performing a single sieve analysis of the fine aggregate.

Obtaining and testing individual size fractions (Method B) is more time-consuming and requires a larger initial sample than using the graded sample. However, Method B provides additional information concerning the shape and texture characteristics of individual size fractions.

Testing samples in the as-received grading

(Method C) may be useful in selecting proportions of the components used in a variety of mixtures. In general, high void content suggests that the material could be improved by providing additional fine aggregate or more binder may be needed to fill the voids between particles.

The bulk dry specific gravity of the fine aggregate
05 (G_{sb}) is used to calculate the void content. The effectiveness of these methods of determining void content and its relationship to particle shape and texture depend on the bulk specific gravity of the various size fractions being equal (or nearly so).

Void content information from Methods A, B, and C may be a useful indicator of properties such as:

- Mixing water demand of hydraulic cement concrete.
- Flowability, pumpability, or workability of grouts and mortars.
- The effect of fine aggregate on stability, strength and VMA in bituminous concrete.
- Stability and strength of base course material.

06 **Apparatus**

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- **Cylindrical Measure:** A right cylinder of approximately 100 mL capacity having an inside diameter of approximately 1.5 inches and an inside height of approximately 3.4 inches made of drawn copper water tube. The bottom of the measure shall be at least 0.25 inches thick, shall be firmly sealed to the tubing, and shall be provided with the means for aligning the axis of the cylinder with that of the funnel. Determine the volume of the measure to the nearest 0.1 mL.
- **Funnel:** A funnel such that the lateral surface of the right frustrum of the cone is sloped 60 $\pm 4^{o}$ from the horizontal with an opening 0.5 ±0.02 inches diameter. The funnel section shall be a piece of metal, smooth on the inside, and at least 1.5 inches high. It shall have a volume of at least 200 mL, or shall be provided with a supplemental container to provide the required volume.

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- **Funnel stand:** A three or four-legged support capable of holding the funnel firmly in position

with the axis of the funnel collinear (within 4^{o} angle and a displacement of 0.07 inches) with the axis of the cylinder measure. The funnel opening shall be 4.5 inches above the top of the cylinder.

- **Glass Plate:** A square glass plate approximately 2.3 by 2.3 inches with a minimum 0.15-inch thickness.
- 09 **Pan:** A metal or plastic pan of sufficient size to contain the funnel stand and prevent loss of material.
- **Spatula:** A metal spatula with a blade approximately 4 inches long and at least 0.75 inches wide, with straight edges. The end shall be cut at a right angle to the edges.
- **Balance:** A balance with a capacity of 1000 g and sensitive to ±0.1 g.

Sample

- 10 The samples used for this test shall be obtained using AASHTO T 2 and AASHTO T 248, or from sieve analysis samples used for AASHTO T 27, or from an extracted bituminous concrete sample.
- 11 For Methods A and B, the sample is washed over a No. 100 or No. 200 sieve in accordance with AASHTO T 11 and then dried and sieved into separate size fractions according to AASHTO T 27. Maintain the necessary size fractions obtained from one or more sieve analyses in a dry condition in separate containers for each size.
- For Method C, dry a split of the as-received sample in accordance with the drying provisions of AASHTO T 27.

Sample Preparation

12 • **Method A – Standard Graded Sample**

Weigh out and combine the following quantities of fine aggregate that has been dried and sieved in accordance with AASHTO T 27.

Individual Size Fraction	Mass, g
No. 8 to No. 16	44 ±0.2
No. 16 to No. 30	57 ±0.2
No. 30 to No. 50	72 ±0.2
No. 50 to No. 100	17 ±0.2
	190 ±0.2

• **Method B – Individual Size Fractions**

Prepare a separate 190 g sample of fine aggregate, dried and sieved in accordance with
13 AASHTO T 27 for each of the following size fractions:

Individual Size Fraction	Mass, g
No. 8 to No. 16	190 ±1
No. 16 to No. 30	190 ±1
No. 30 to No. 50	190 ±1

Do not mix fractions together. Each size is tested separately.

• **Method C – As-received Grading**

Pass the sample (dried in accordance with AASHTO T 27) through a No. 4 sieve. Obtain
14 a 190 ±1 g sample of this material for the test.

Specific Gravity of Fine Aggregate

15 If the bulk specific gravity (G_{sb}) of the fine aggregate from the source is unknown, determine it according to AASHTO T 84. Use this value in subsequent calculations unless some size fractions differ by more than 0.05 from the specific gravity typical of the sample, in which case the specific gravity of the fraction(s) must be determined.

Procedure

16 1. Record all masses to the nearest 0.1 g.
2. Record the mass of the empty measure
3. Mix each test sample with the spatula until it appears to be homogeneous.
4. Position the jar and funnel section in the stand

and center the cylindrical measure with the axis of the funnel. Use a finger to block the opening of the funnel.

5. Pour the test sample into the funnel. Level the material in the funnel with the spatula.

17 6. Remove the finger and allow the sample to freely flow into the cylindrical measure.

7. After the funnel empties, strike off excess from the top of the cylindrical measure by a single pass of the spatula with the width of the blade vertical, using the straight part of its edge in light contact with the top of the measure. Until this operation is complete, avoid vibration or disturbance that could cause compaction of the fine aggregate in the measure (see note).

Note 1: After strike-off, the cylindrical measure may be tapped lightly to compact the sample for easier transport of the container to the scale or balance without loss of any sample.

18 8. Brush adhering grains from the outside of the cylindrical measure. Determine the mass of the measure and its contents to the nearest 0.1 g.

9. Recombine the sample from the retaining pan and cylindrical measure, repeat the procedure, and average the results of the two test runs.

Calculation

19 Calculate the uncompacted voids for each determination according to the following formula:

$$U = \frac{V - \left(\frac{F}{G}\right)}{V} \times 100$$

where:

U = uncompacted voids, percent, in the material;

V = volume of cylindrical measure, mL;

F = net mass of fine aggregate in measure, g; and,

G = bulk specific gravity (G_{sb}) of aggregate

20 **For Methods A and C:** Calculate the average uncompacted voids for the two determinations.

For Method B: First determine the uncompacted void content for each of the individual size fractions; then calculate the mean uncompacted void content as follows:

$$U_m = \frac{U_1 + U_2 + U_3}{3}$$

where:

U_m = Mean uncompacted void content, %

U_1, U_2, U_3 = Uncompacted void content of individual size fractions

Calculation Examples

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$$U = \frac{99.8 - \left(\frac{146.2}{2.636}\right)}{99.98} \times 100 = 44.43, \text{ say } 44.4\%$$

where:

U = Uncompacted void content, %;
V = 99.8 mL
F = 146.2 g.
G = 2.636

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$$U_m = \frac{48.7 + 49.9 + 47.0}{3} = 48.53, \text{ say } 48.5\%$$

where:

U_m = Mean uncompacted void content, %
U_1 = 48.7%
U_2 = 49.9%
U_3 = 47.0%

Report

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- Results shall be reported on standard agency forms to the nearest 0.1 percent.
- Method used
- Material source and description
- Sample mass
- Bulk specific gravity used

Tips!

- Check agency specifications for method to be used, “A,” “B,” or “C” 24
- Level the material in the funnel
- Strike-off the measure with a single pass of the spatula
- Tapping the cylindrical measure after striking off will help prevent loss while handling

REVIEW QUESTIONS

1. Describe the sample used for Method A.

2. Describe the difference(s) between Method C and Method A?

3. What information is required to perform the Method A uncompacted void calculation?

4. After material is placed in the funnel, what is the next step?

5. After the first test run, how many times is the test repeated to calculate the average uncompacted void content?

6. Describe how the strike-off of the cylindrical measure is performed.

PERFORMANCE EXAM CHECKLIST

UNCOMPACTED VOID CONTENT OF FINE AGGREGATE
FOP FOR AASHTO T 304

Participant Name:_________________________ Exam Date:____________________

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element **Trial 1** **Trial 2**

Sampling

1. **Sample obtained by one of the following:**

(a) T 2 & T 248 (sampling, splitting and quartering)? ______ ______

or (b) From sieve analysis samples used for T 27? ______ ______

or (c) From aggregate extracted from a bituminous concrete specimen (T 308)? ______ ______

2. **Methods A and B:**

(a) Sample washed over No. 100 or No. 200 sieve in accordance with T 11? ______ ______

(b) Sample dried and sieved into separate size fractions in accordance with T 27? ______ ______

(c) Necessary size fractions obtained from sieve analysis maintained in a dry condition in separate containers for each size? ______ ______

Method C:

(a) A split of the as-received sample dried in accordance with the drying procedure of T 27? _____ ______

Sample Preparation

Method A- Standard Graded Sample

1. Following quantities of aggregate that has been dried and sieved in accordance with T 27 weighed out and combined? ______ ______

Individual Size Fractions	Mass, g	OK?
No. 8 to No. 16	44 ± 0.2	
No. 16 to No. 30	57 ± 0.2	
No. 30 to No. 50	72 ± 0.2	
No. 50 to No. 100	17 ± 0.2	
Total:	190 ± 0.2	

Method B- Individual Size Fractions

1. Separate 190 g sample of aggregate prepared for each of the following size fractions?

Individual Size Fractions	Mass, g	OK?
No. 8 to No. 16	190 ± 1	
No. 16 to No. 30	190 ± 1	
No. 30 to No. 50	190 ± 1	

2. Samples not mixed together, but each size saved for separate testing?

	Trial 1	Trial 2
Method C- As Received Grading		
1. Sample passed through No. 4 sieve?	______	______
2. Representative sample of 190 ± 1 g. obtained from minus No. 4 sieve?	______	______
Specific Gravity of Fine Aggregate		
1. If bulk dry specific gravity of aggregate from the source is unknown, specific gravity determined on material passing No. 4 sieve in accordance with T 84?	______	______
2. This value used in subsequent calculations unless some size fractions(s) being tested must be determined?	______	______
3. If specific gravity differences between size fractions exceed 0.05:		
(a) Specific gravity of the individual No. 8 to No. 100 sizes determined for use with Method A or the individual size fractions for use with Method B?	______	______
(b) Specific gravity determined by direct measurement or by calculation using specific gravity data on gradings with and without the size fraction of interest?	______	______
Procedure		
1. Each test sample mixed with spatula until it appears to be homogeneous?	______	______
2. Funnel stand apparatus with cylindrical measure, positioned in retaining pan?	______	______
3. Finger used to block opening of funnel?	______	______
4. Test sample poured into funnel?	______	______
5. Material in funnel leveled with spatula?	______	______
6. After funnel empties, excess heaped aggregate struck off from cylindrical measure by single pass of spatula, with blade width vertical and using straight part of its edge in light contact with top of measure?	______	______
7. Care exercised to avoid vibration or any disturbance that could cause compaction of aggregate into cylindrical measure?	______	______
Note: *After strike-off, measure may be tapped lightly to compact sample to make it easier to transfer container to scale or balance without spilling any of the sample.*		
8. Adhering grains brushed from outside of container?	______	______
9. Mass of cylindrical measure and contents determined to nearest 0.1 g?	______	______
10. All aggregate particles retained for second test run?	______	______
11. Sample from retaining pan and cylindrical measure recombined and procedure repeated?	______	______
12. Mass of empty measure recorded?	______	______
13. Calculations performed properly?	______	______

Formula for Calculation of Uncompacted Voids, percent

$$U = \frac{V - \left(\frac{F}{G}\right)}{V} \times 100$$

where:

U = uncompacted voids, percent;
V = volume of cylindrical measure to nearest 0.1 mL;
F = net mass, g, of fine aggregate in measure; and,
G = bulk dry specific gravity of fine aggregate (G_{sb})

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

Signature of Examiner____________________________________.